Claims

What is claimed is:

1. Apparatus for forming a dye sublimation image in a substrate with a dye carrier having an image formed thereon of a sublimatic dyestuff, the apparatus comprising:

a platen, for disposing thereon the substrate, the substrate having further disposed thereon the dye carrier such that the sublimatic dyestuff is in contact with the substrate;

a membrane for covering the substrate, the dye carrier, and at least a portion of the platen;

a clamping system for applying, with the membrane, a uniform clamping pressure to the substrate and the dye carrier;

a heating device for heating the substrate and the dye carrier from their ambient temperature to a first temperature and for a period of time requisite to form the image in the substrate; and

a cooling device for cooling the substrate and the dye carrier to a second temperature following the heating thereof.

2. Apparatus for forming a dye sublimation image in a substrate utilizing a dye carrier having an image formed thereon of a sublimatic dyestuff, the apparatus comprising:

a platen, for disposing thereon a substrate, the substrate having further disposed thereon a dye carrier such that the sublimatic dyestuff is in contact with the substrate;

a membrane for covering the substrate, the dye carrier, and at least a portion of the platen;

an atmospheric clamping system for applying, in operative combination with the membrane, a uniform clamping pressure to the substrate and the dye carrier;

a heating device for heating the substrate and the dye carrier from their ambient temperature to a first temperature and for a period of time requisite to form the image in the substrate while the uniform clamping pressure is applied to the substrate and the dye carrier; and

a cooling device for cooling the substrate and the dye carrier to a second temperature while the uniform clamping pressure is applied to the substrate and the dye carrier, following the heating thereof.

3. The apparatus of Claim 2 wherein the heating device further comprises a radiant heating element.

4. The apparatus of Claim 3 wherein the radiant heating element is selected from the group consisting of infrared lamp and microwave source.

5. The apparatus of Claim 3 wherein the heating device is selected from the group consisting of: radiant heating device, conductive heating device, convective heating device, and the application of open flame.

6. The apparatus of Claim 2 wherein the heating device further comprises a conductive heating device.

7. The apparatus of Claim 6 wherein the conductive heating device further comprises:

a thermally conductive plate; and

means for heating the thermally conductive plate.

8. The apparatus of Claim 6 further comprising

a thermally conductive plate rendered partially hollow by the formation therein of at least one chamber;

a heater for providing a controllable flow of heated fluid through the chamber of the thermally conductive plate; and

a quantity of fluid at least partially filling the chamber of the thermally conductive plate, and rendered controllably heatable by the heater.

9. The apparatus of Claim 8 wherein the fluid is selected from the group consisting of gas and liquid.

10. The apparatus of Claim 2 further comprising a spectacle frame, having the membrane mounted therein.

11. The apparatus of Claim 10 further comprising a platen assembly formed by hingedly attaching one side of the spectacle frame one side to the platen.

12. The apparatus of Claim 2 further comprising:

a thermal imaging unit for receiving therein the platen assembly; and

the heating device disposed within the thermal imaging unit.

13. The apparatus of Claim 12 wherein the heating device further comprises:

a thermally conductive plate; and

means for heating the thermally conductive plate.

14. The apparatus of Claim 13 further comprising:

a table having the thermal imaging installed thereon;

means for positioning the platen assembly with respect to the thermal imaging unit;

a press for urging the thermally conductive plate into intimate contact with the membrane; and

a retractor for retracting the thermally conductive plate from the membrane.

15. The apparatus of Claim 14 wherein the cooling device is disposed within the thermal imaging unit.

16. The apparatus of Claim 14 wherein the cooling device is disposed in a housing separate from the thermal imaging unit.

17. The apparatus of Claim 14 wherein the cooling device is a passive cooling device.

18. The heating device of Claim 2 wherein the cooling device further comprises a passive cooling device.

19. The apparatus of Claim 18 wherein the passive cooling device further comprises a low thermal mass panel in contact with at least a portion of at least one surface of the substrate.

20. The apparatus of Claim 2 wherein the cooling device further comprises an active cooling device.

21. The apparatus of Claim 20 wherein the active cooling device further comprises:

a thermally conductive plate for contacting at least one of the membrane and the substrate and for conductively cooling at least the substrate; and

a cooling system for cooling the thermally conductive plate.

22. The apparatus of Claim 21 further comprising:

the thermally conductive plate defining therein at least one internal cavity;

a quantity of coolant disposed within and circulating throughout the internal cavity of the thermally conductive plate; and

the cooling system further for cooling and for circulating the quantity of coolant.

23. The apparatus of Claim 22 wherein the coolant is selected from the group consisting of coolant liquid and coolant gas.

24. The apparatus of Claim 2 wherein the atmospheric clamping system further comprises means for inducing a positive pressure differential between the membrane and a space between the membrane and the platen, the space containing therein the substrate and the dye carrier.

25. The apparatus of Claim 24 wherein the atmospheric clamping system further comprises a vacuum system for inducing a vacuum in the space between the membrane and the platen, and hence applying a clamping force to the substrate and the dye carrier with the membrane.

26. The apparatus of Claim 24 wherein the atmospheric clamping system further comprises a pressure system for inducing a pressure on a side of the membrane opposite the space between the membrane and the platen, and hence applying a clamping force to the substrate and the dye carrier with the membrane.

27. The apparatus of Claim 24 wherein the atmospheric clamping system further comprises:

a vacuum system for inducing a vacuum in the space between the membrane and the platen, and hence applying a clamping force to the substrate and the dye carrier with the membrane; and

a pressure system for inducing a pressure on a side of the membrane opposite the space between the membrane and the platen, the pressure system reinforcing the clamping force induced by the vacuum system.

28. The platen assembly of claim 11 configured to receive in a space between the membrane and the platen a plurality of substrate-dye carrier pairs arranged as a stack.

29. The platen assembly of claim 28 further comprising a clamp device for clamping the spectacle frame to the platen.

30. The apparatus of claim 2 wherein the membrane is a flexible membrane.

31. The apparatus of claim 30 wherein the flexible membrane is selected from the group consisting of fabric, coated fabric, plastic, coated plastic, metalized plastic, and metal.

32. The apparatus of claim 2 wherein the membrane is an elastomeric membrane.

33. The apparatus of Claim 32 wherein the elastomeric membrane is selected from the group consisting of: rubber, vulcanized rubber, silicone rubber, butyl rubber, plastic, foam rubber, polymer, monomer, chloropolymer, fluoropolymer, and man-made elastomeric sheet.

34. The apparatus of Claim 14 wherein the press is selected from the group consisting of: hydraulic cylinder, pneumatic cylinder, magnetic urging device, electromagnetic urging device, bag press, camshaft, crankshaft, screw, helical shaft, and wedge.

35. Apparatus for forming a dye sublimation image in a rigid plastic substrate having a specific set of technical performance specifications, said image formed with a dye carrier having a reverse image formed thereon of a sublimatic dyestuff, said apparatus comprising in operative combination:

a platen assembly including a platen defining at least one perforation therethrough and a spectacle frame hingedly attached to one side of said platen, said spectacle frame defining an aperture;

an elastomeric membrane disposed over said aperture for covering at least a portion of said platen and said substrate and said dye carrier when said substrate and said dye carrier are disposed on said platen;

a first thermally conductive plate rendered partially hollow by the formation therein of at least one chamber;

a heater for providing a controllable flow of a heating fluid through said chamber of said first thermally conductive plate; and

a quantity of said heating fluid at least partially filling said chamber of said first thermally conductive plate, said quantity of said heating fluid rendered controllably heatable by said heater;

a table for receiving thereon said platen assembly;

disposed on said table, a thermal imaging unit defining a first passage therein, said thermal imaging unit having said first thermally conductive plate disposed therein whereby said first thermally conductive plate is rendered capable of reversible downward motion;

positioning means for reversibly positioning said platen assembly within said first passage and in substantial alignment with said first thermally conductive plate;

a first press disposed within said thermal imaging unit for reversibly urging said first thermally conductive plate into contact with said membrane;

first retractor spring further disposed within said first passage for reversibly retracting said thermally conductive plate from contact with said membrane;

a second thermally conductive plate rendered partially hollow by the formation therein of at least one chamber;

a cooler for providing a controllable flow of a coolant through said chamber of said second thermally conductive plate; and

a quantity of said coolant at least partially filling said chamber of said second thermally conductive plate, said quantity of said coolant rendered controllably coolable by said cooler;

further disposed on said table, a cooling unit defining a second passage therein, said cooling unit having said second thermally conductive plate disposed therein whereby said second thermally conductive plate is rendered capable of reversible downward motion;

second positioning means for reversibly positioning said platen assembly within said second passage and in substantial alignment with said second thermally conductive plate;

a second press disposed within said cooling unit for reversibly urging said second thermally conductive plate into contact with said membrane;

a second retractor spring further disposed within said second passage for reversibly retracting said second thermally conductive plate from contact with said membrane; and

a control unit for controlling at least one of a temperature of said first thermally conductive plate, a first time interval where said first thermally conductive plate is urged into contact with said membrane, a temperature of said second thermally conductive plate, and a second time interval where said second thermally conductive plate is urged into contact with said membrane,

whereby said image is formed within said substrate by means of dye sublimation, without degradation of any of said technical performance specifications of said substrate.

36. A method for forming a dye sublimation image in a substrate with a dye carrier having an image formed thereon of a sublimatic dyestuff, the method comprising:

disposing the substrate on a platen;

disposing the dye carrier on the substrate such that the sublimatic dyestuff is in contact with the substrate;

covering the substrate, the dye carrier, and at least a portion of the platen with a membrane;

applying a uniform clamping pressure to the substrate and the dye carrier with the membrane;

heating the substrate and the dye carrier from their ambient temperature to a first temperature for a period of time requisite to form the image in the substrate; and

following the heating of the substrate and the dye carrier, cooling the substrate and the dye carrier to a second temperature.

37. The method of Claim 36 applied to a rigid plastic substrate having a specific set of technical performance specifications, whereby the method results in the image being formed in the rigid plastic substrate without degradation of any of the technical performance specifications of the rigid plastic substrate.

38. The method of Claim 37 wherein:

heating the rigid plastic substrate to a temperature above the plastic substrate's rigid state; and

cooling the plastic substrate returns the plastic substrate to its rigid state.

39. The method of Claim 36 where applying a uniform clamping pressure to the substrate and the dye carrier with the membrane is accomplished by inducing a pressure differential between the ambient atmosphere and the atmosphere under the membrane.

40. A method for forming a dye sublimation image in a solid substrate utilizing a dye carrier having thereon a sublimatic dyestuff, the method comprising:

superposing the substrate over a platen;

disposing the dye carrier on the substrate such that the sublimatic dyestuff is in contact with the substrate;

covering the substrate, the dye carrier, and at least a portion of the platen with a membrane;

inducing a positive pressure differential between the ambient atmosphere above the membrane and the atmosphere under the membrane, thereby applying a clamping pressure to the substrate and the dye carrier with the

membrane, urging the dye carrier into intimate contact with the solid substrate, and urging the substrate into a substantially planar form;

heating the substrate and the dye carrier from their ambient temperature to a first elevated temperature for a period of time requisite to form an image in the substrate from the sublimatic dyestuff while continuing to urge the substrate into the substantially planar form; and

following the heating of the substrate and the dye carrier, cooling the substrate and the dye carrier to a second, lowered temperature while continuing to urge the substrate into the substantially planar form.

41. The method of Claim 40 wherein inducing a positive pressure differential between the ambient atmosphere above the membrane and the atmosphere under the membrane further comprises applying pressure to the upper surface of the membrane.

42. The method of Claim 40 wherein inducing a positive pressure differential between the ambient atmosphere above the membrane and the atmosphere under the membrane further comprises forming a vacuum beneath the membrane.